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Part III

Veterans Administration

Standards for Electrically Powered Wheelchairs

VETERANS ADMINISTRATION

Standards for Electrically Powered Wheelchairs

AGENCY: Veterans Administration.

ACTION: Notice of Publication of Standards and Request for Comments.

SUMMARY: Notice is hereby given of the proposed publication of the Veterans Administration Standards for Electrically Powered Wheelchairs in the Bulletin of Prosthetics Research. These standards are to provide an evaluation base for electrically powered wheelchairs and to ensure a functional wheelchair which is safe, comfortable and durable. These Veterans Administration Standards for Electrically Powered Wheelchairs establish minimum standards for the classification, selection, and purchase of electric wheelchairs, by the Veterans Administration, for use by veteran beneficiaries. The Bulletin of Prosthetics Research is published by the Rehabilitation Engineering Research and Development Service, Department of Medicine and Surgery, Veterans Administration. The Bulletin is published semi-annually and is available through the Government Printing Office. These Standards are scheduled for publication in the Spring, 1982 edition.

DATES: Comments must be received by December 31, 1981. It is proposed that all electrically powered wheelchairs submitted for qualification under these Standards meet the requirements contained therein by February 25, 1982.

ADDRESSES: Interested persons are invited to submit written comments regarding these Standards to the address below. Testing equipment and techniques may also be viewed at the same site.

Director, VA Rehabilitation Engineering Center, 252 Seventh Avenue, New York, NY 10001.

Dated: December 7, 1981.

Robert P. Nimmo,

Administrator.

Veterans Administration Standards for Electrically Powered Wheelchairs

December 1980

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1.0. *Scope, Classification, Limitations, Definitions.*

1.1. *Scope.* This Standard applies to electrically powered wheelchairs for use by entitled veteran beneficiaries. Intended for VA use, this document sets minimum standards for the classification, selection, and purchase of electric wheelchairs suited to veteran needs. While other persons and agencies may use this document for reference, it is to be understood that this document is not intended for eventual use as an American National Standard. Thus, the VA disclaims any responsibility arising from use of the following material by any person not affiliated with the VA.

1.2. *Classification and Qualification.* Powered wheelchairs shall be classified according to performance capability. There shall be three classes:

Class I wheelchairs carrying a 200-lb. (90.7 kg) person shall attain a maximum speed of between 2.5 and 4.0 mi/h (4.0 and 6.4 km/h) on level ground, be capable of climbing a slope of not less than 6 deg., travel a distance of at least 6 mi. (9.7 km) between battery charges, and be able to clear a 1-inch high obstacle from a moving start.

Class II wheelchairs carrying a 200-lb. (90.7 kg) person shall attain a maximum speed of between 4.0 and 6.0 mi/h (6.4 and 9.7 km/h) on level ground, climb a slope of not less than 9 deg., travel a minimum distance of 10 mi. between battery charges, and clear a 2-in. (5.1 cm) high obstacle from a moving start.

Class III wheelchairs shall be capable of all the functions performed by Class II wheelchairs while carrying a 250-lb. (113 kg) person.

Wheeelchairs covered by this Standard shall be classified and qualified for use by veteran beneficiaries by means of laboratory and field tests. Compliance with certain Standards shall be determined by observation, measurement, and inspection. Wheelchairs deviating from the Standard in some minor fashion that are found to be satisfactory as a result of clinical testing shall be deemed acceptable.

1.2.1. *Requirements.* Electrically powered wheelchairs covered by this Standard shall meet the same mechanical requirements as the self-propelled folding wheelchairs covered under Veterans Administration Standard (**Federal Register,** Vol. 42, No. 239, Tuesday, December 13, 1977) with respect to strength, durability, safety, adjustability, stability, casters, brakes, locks, and maneuverability. Curb-drop tests and weight requirments are excluded. They shall also meet additional Standards, listed below, concerning electrical and mechanical performance and safety. A manual describing control and performance characteristics, together with maintenance guides including wiring diagrams, shall be furnished with each wheelchair as given in Para. 8.1. (Documentation), below.

Rationale. It is assumed that electrically powered wheelchairs covered by this Standard will be used in the same environments where manually propelled (non-powered) wheelchairs are used. Requirements for Structural integrity and stability of powered wheelchairs, therefore, should be similar to those specified for manually propelled wheelchairs, notwithstanding the additional weight of the motors and batteries.

1.2.2. *Laboratory Tests.* Laboratory tests shall be performed with motors, controls, and batteries mounted in their normal positions. Batteries may be filled with water instead of acid electrolyte during mechanical tests for the convenience and safety of laboratory personnel. Performance tests shall be conducted with fully charged,

mechanically and electrically sound batteries.

1.2.3. *Field Tests.* Wheelchairs qualified under this Standard will be tested under field conditions in actual use. Observations and data collected during these field tests shall provide the basis for evaluating safety, utility, and performance characteristics. These tests will be conducted in hospital, home, and outdoor environments. Wheelchairs which do not meet the safety requirements during laboratory testing will not be field tested. Wheelchairs, covered by this Standard, which are essentially similar to previously qualified models may be qualified without field testing.

1.3. *Limitations.* These Standards do not cover conveyances designed exclusively for outdoor use.

1.4. *Definitions.*

1.4.1. *Acceleration.* The rate of change of velocity with respect to time expressed in terms of the acceleration (i.e., G) due to gravity. For example, 0.4G denotes an acceleration equal to 40 percent of that due to gravity.

1.4.2. *Add-On Power Packs.* Assemblies of motors, power trains, controllers, mounting brackets, and batteries intended for attachment to manually propelled wheelchairs in order to convert them to electrically powered wheelchairs.

1.4.3. *Anthropomorphic Dummy.* A dummy of the dimensions, proportions, and weight distribution of a typical male body.

1.4.4. *Brake.* A mechanical or electromechanical system for applying friction to the wheels or drive system of a wheelchair to retard its motion. Brakes are different from wheelchair locks which prevent a stationary wheelchair from moving.

1.4.5. *Disengagement.* The release of a power train from connection to the drive wheels to permit free wheeling.

1.4.6. *Regenerative Braking.* Regenerative braking uses the electromagnetic characteristics of the motors to brake a wheelchair. The inertial energy of the wheelchair is converted to electrical energy and, in the process, the motion of the wheelchair is retarded.

1.4.7. *Flutter.* To move in quick oscillating motion; vibrate. As used in this Standard, flutter generally refers to the oscillating movement of caster wheels about a vertical axis.

1.4.8. *Jerk.* The rate of change of acceleration with respect to time, or the third derivative of distance with respect to time. This quantity, a useful measure of the disturbing impetus given the user when operating the controls, is given in G per second. For example, a jerk of 5G/sec. means that the rate of change of acceleration is equal to five times the acceleration due to gravity in one second.

1.4.9. *Latching (Holding).* A control method in which a momentary signal turns a function on until another momentary signal turns the same function off.

1.4.10. *May.* Discretionary.

1.4.11. *Momentary.* A control method which actuates a function for the duration of an input signal.

1.4.12. *Power Train.* A system or component to transmit power from a motor to a drive wheel, i.e., gears, belts, chains, etc.

1.4.13. *Quiescent-Energy Drain.* The battery-energy discharge through the control circuit when the wheelchair is not in motion; the main power switch is turned on, and the controller does not transmit power to the drive system. This is the normal energy-drain characteristic of proportional electronic controls.

1.4.14. *Shall.* Mandatory.

1.4.15. *Short Circuit.* A condition of low resistance between two points in a circuit resulting in excess current.

1.4.16. *Should.* Desirable.

1.4.17. *Stability.* A condition in which a vertical projection of the center of gravity of a system falls within its base support. As used in this Standard, it refers to resistance to toppling or other, unwanted, rotational motion.

1.4.18. *Steady State.* An operational condition which does not change significantly with time. The term as used in this Standard refers to uniform rates of energy consumption or uniform velocity.

1.4.19. *Surge.* A large sudden change of current or voltage.

1.4.20. *Volt-Ampere (Watt).* An electrical unit equal to the product of one volt and one ampere. DC operation is assumed.

1.4.21. *Wheelie.* A maneuver in which a wheelchair is momentarily balanced on its rear drive wheels. Given sufficient amplitude of front wheel lift-off, a condition of catastrophic instability may result wherein the wheelchair may tilt backward, and the occupant become injured.

2.0. *Performance.*

2.1. *Speed.*

2.1.1. *Standard.* Powered wheelchairs shall attain a certain minimum speed but shall not exceed a maximum. Speed values shall reflect class designation.

2.1.2. *Specification.* On smooth level terrain, Class I wheelchairs shall attain a maximum speed of not less than 2.5 mi/h (4.0 km/h), but not more than 4.0 mi/h (6.4 km/h), while carrying a test load of 200 lbs. (90.7 kg). On similar terrain, Class II wheelchairs shall attain a maximum speed greater than 4.0 mi/h (6.4 km/h), but not greater than 6.0 mi/h (9.7 km/h), while carrying a 200-lb. (90.7 kg) test load. A Class III wheelchair shall perform as a Class II wheelchair while carrying a 250-lb. (113 kg) load.

Rationale. Normal walking speed is approximately 3.0 mi/h (4.8 km/h). The maximum speed of a Class I wheelchair should be similar to, or slightly greater than, ordinary walking speed. Properly trained wheelchairs users can safely manage speeds of 6.0 mi/h (9.7 km/h) provided by Class II and Class III wheelchairs.

2.1.3. *Speed Tests.* Speed measurements shall be conducted in a straight line on hard, flat, horizontal surfaces. Test loads shall consist of an anthropomorphic dummy or a test subject with a sufficient, additional, inanimate load to meet the weight requirements of Para. 2.1.2. Maximum speed shall be measured over a 50-ft. (15.2 m) distance entered at full speed. An automatic timing procedure, i.e., optical or load-sensor triggering, is recommended. If stopwatch time measurements are to be used, the average elapsed time taken from two independent observations will be obtained. If a wheelchair is equipped with pneumatic tires, then proper pressure shall be assured for each tire during the tests.

2.2. *Inclined Surfaces.*

2.2.1. *Standard.* Powered wheelchairs shall be capable of ascending inclined surfaces.

2.2.2. *Specification.* Class I wheelchairs shall climb inclined surfaces of at least 6 deg. (10.5% slope) with a standard test load (Para. 2.1.2.). Starting from a dead stop, Class I wheelchairs shall achieve a final velocity of at least 1.5 mi/h (2.4 km/h). Class II and Class III wheelchairs shall climb inclined surfaces of at least 9 deg. (15.8% slope) with a final speed of at least 2.0 mi/h (3.2 km/h).

Rationale. Most hospital entrance slopes do not exceed 6 deg. (10.5% slope), and the inclined surface requirements will probably be adequate to meet most barrier-free environments. (ANSI A 117.1–1951 (R 1971)). The UMPTA Standard for bus ramps is 9.0 deg. (15.8% slope); Class II and Class III wheelchairs should be capable of climbing such ramps.

2.2.3. *Inclined-Surface Test.* The inclined surface shall be hard, flat, and of the non-skid type. Length shall be sufficient to permit the wheelchair to be driven 30.0 ft. (9.1 m) in a straight line. The wheelchair, plus standard load, shall accelerate from a standing start at the bottom of the ramp with the

controller set at maximum speed. The time to traverse the central 10-ft. (3.05 m) span will be used to gauge velocity. The means of measuring velocity shall be those given in Para. 2.1.3.

2.3. *Range.*

2.3.1. *Standard.* Powered-wheelchair range (distance traversed on a single battery charge) shall be suitably large and shall reflect the classification of the wheelchair.

2.3.2. *Specification.* Class I wheelchairs shall travel a minimum of 6.0 mi. (9.6 km) on hard, flat, horizontal surfaces on a single battery charge. Class II and Class III wheelchairs shall travel a minimum distance of 10.0 mi. (16.1 km) on a single charge. All wheelchairs shall achieve the indicated ranges for 20 complete cycles. Each cycle shall start with the same batteries in a fully charged state. Weightload conditions shall be as given in Para. 2.1.2. Manufacturers shall recommend appropriate battery types, sources of supply, and case sizes to meet range requirements, or the manufacturer shall provide appropriate batteries with wheelchairs.

Rationale. Typical, daily, indoor use should not require an electrically powered wheelchair to travel more than 6.0 mi. (9.6 km) since this distance is comparable to values covered daily by normal walkers. Thus, a 6.0-mi. (9.6 km) range for Class I wheelchairs is sufficient. Class II and Class III wheelchairs offer greater performance by definition; the 10-mi. (16.1 km) range requirement reflects the additional performance requirement.

The Range Test, given below, is designed to be conducted in conjunction with the Electrical-Energy Conductance Test (Para. 3.5.2.).

2.3.3. Range Test. The wheelchair is to be equipped with a standard test load (Para. 2.1.2.) and driven over a relatively high-friction, horizontal, flat, hard course at an average speed equal to, or exceeding, two-thirds maximum speed. Long stops acting to promote battery recovery and component temperature drop are not desirable; should the stopped time exceed one minute in the course of a given range test, the result shall be unacceptable. Course layout shall employ a tape measure or calibrated odometer. Should the course be small in comparison to the range, lap counting is an acceptable measure of distance. The test will terminate when either the desired range is achieved or the batteries are incapable of propelling the wheelchair, plus test load, at two-thirds maximum speed.

2.4. *Dynamic Characteristics.* Dynamic characteristics refer to wheelchair performance and stability of the occupant and wheelchair when the motion of the wheelchair changes in magnitude and/or direction.

2.4.1. *Standard.* Wheelchair dynamic characteristics shall not cause discomfort or loss of stability to the user.

2.4.2. *Specification.* The horizontal acceleration of a powered wheelchair shall be essentially uniform and not cause any disturbance which may adversely affect the occupant's control over his motion and stability and of the wheelchair. Maximum, horizontal, wheelchair acceleration shall not exceed 0.6G. Horizontal jerk shall not exceed 10.0G/sec.

Rationale. Sudden changes in motion (acceleration or deceleration) by a marginally stable wheelchair with an occupant, especially on inclines, may create a dangerous condition; this may be exacerbated by users with atypical, anatomical, weight distribution such as amputees.

2.4.3. *Dynamic-Characteristic Test.* The acceleration value to be measured is the maximum value developed from a standing start by the wheelchair while carrying a standard test load consisting of a male driver, plus sufficient dead load, to bring the total to specified standards (Para. 2.1.2.). A commercial servoaccelerometer is to be fastened firmly to the frame of the wheelchair. The control stick is to be moved forward as rapidly as possible by the wheelchair occupant. Accelerometer results are to be recorded as a function of time using an appropriate high-frequency response oscillograph or an oscilloscope. Should the base line shift in the course of the run, the implication is that the accelerometer attitude has changed; the test is unacceptable. An average of five successful readings is required to establish the desired acceleration value. Jerk is to be determined by graphically differentiating the acceleration versus time record, described above, in the conventional manner.

2.5. *Level Braking.*

2.5.1. *Standard.* The powered wheelchair shall be capable of decelerating in a safe comfortable manner from maximum velocity.

2.5.2. *Specification.* Class I wheelchairs shall not roll less than 1 ft. (.30 m), or more than 3 ft. (.91 m), on a smooth, hard, horizontal surface after release of the speed control while undergoing maximum velocity under rated load conditions (Para. 1.2.).

Class II wheelchairs shall not roll less than 3 ft. (.91 m), or more than 6 ft. (1.83 m), on a horizontal surface after release of the speed control while undergoing maximum velocity under rated load conditions (Para. 1.2.).

Class III wheelchairs shall not roll less than 4 ft. (1.22 m), or more than 8 ft. (3.05 m), on a horizontal surface after release of the speed contrtol while undergoing maximum velocity under rated load conditions (Para. 1.2.).

Maximum deceleration in each class test shall not exceed 0.6G.

Rationale. With power suddenly removed, whether or not intended (e.g., zero-command input), wheelchairs in motion may stop abruptly or tend to coast excessively. Such potentially undesirable motions should be controlled to assure the safety and comfort of the occupant. Regenerative braking or other types of braking involving the mechanical resistance of gear trains and the sliding contact of high-friction surfaces are all acceptable means of decelerating the wheelchair.

2.5.3. *Level-Braking Test.* The wheelchair, plus proper test load, shall be driven at maximum velocity on a hard, flat, horizontal surface. When a marker is reached, the driver is to release the control. The distance traversed in coasting to a full stop, obtained through use of a tape measure, is the required, level-braking, test measurement.

2.6. *Ramp Braking.*

2.6.1. *Standard.* Power failure on a ramp shall not produce dangerous forward rolling or backward motion.

2.6.2. *Specification.* Powered wheelchairs carrying proper test loads (Para. 1.2.), when released from a standing start, shall not roll down a 6.0-deg. incline faster than 0.5 mi/h (0.8 km/h).

2.6.3. *Ramp-Braking Test.* The ramp shall be hard, flat, and of a non-skid surface type. Length shall be sufficient to permit the wheelchair to coast 15.0 ft. (4.58 m) in a straight line from the point of release. The time required to traverse the last half of the ramp will be used to gauge velocity. The means of measuring velocity shall be those given in Para. 2.1.2. The starting velocity, at the top of the ramp, shall be zero. Runs are to be conducted with the control system in the "on" position and in the "off" position so as to seek that condition producing the largest ramp-descent velocity. If there is a difference, the largest value measured is to be employed as the final value. The user is not to activate the joystick or other speed regulating means in the course of this test.

3.0. *Electrical Characteristics and Requirements.*

3.1. *Level Ground.*

3.1.1. *Standard.* Electrical consumption rates, expressed in watts, shall reflect reasonable efficiency.

Extraordinary power demands are undesirable.

3.1.2. *Specification.* Level ground electrical-energy drain of all powered wheelchairs shall not exceed 600 watts during steady-state operating conditions or 1500 watts during surges.

Rationale. Surge conditions follow immediately upon the application of power to the drive motors; steady-state conditions exist when the wheelchair achieves uniform motion. Permissible electrical-power values, given above, reflect measurements obtained with the most common powered-drive systems.

It is appreciated that the test, given immediately below (Para. 3.1.3.), may not be precise at low-energy consumption levels. However, it is believed that the testing error is negligible at the maximum-energy levels sought.

3.1.3. *Level Ground Electrical-Consumption Test.* Measurements shall be made with fully charged batteries. The test drive surface shall be hard, flat, and horizontal. The wheelchair shall carry an appropriate test load (Para. 2.1.2.). Voltage and current readings shall be made with meters offering a sufficiently fast response time. Both steady-state and surge-power readings are to be obtained under conditions of full power application to the wheelchair. Surge readings shall be obtained with the wheelchair initially at rest.

3.2. *Ramp Ascent.*

3.2.1. *Standard.* Ramp ascent shall be conducted in an efficient manner.

3.2.2. *Specification.* Ramp-ascent electrical-energy consumption shall not exceed 1000 watts during steady-state conditions or 1500 watts during surges.

3.2.3. *Ramp-Ascent Electrical-Consumption Test.* The test procedure shall be as given in Para. 3.1.3., with the substitution of an appropriate ramp for the prior level surface. Proper ramp angles shall be chosen for each wheelchair class from that description given in Para. 1.2.

3.3. *Quiescent-Energy Drain.*

3.3.1. *Standard.* Quiescent-energy drain shall be minimal.

3.3.2. *Specification.* Quiescent-energy drain shall not exceed 5.0 watts. Indicator lamps, if used, shall not consume more than 0.5 watts each. No current drain shall exist when the main power switch is turned off.

Rationale. Excessive quiescent-energy drain leading to prematurely depleted batteries is clearly undesirable.

3.3.3. *Quiescent-Energy Drain Test.* Conventional voltage and current meters shall be arranged to monitor battery output.

With the main power switch on and all other controls inactive, readings are those of quiescent-energy loss.

3.4. *Short Circuit Protection.*

3.4.1. *Standard.* Wheelchair controllers shall incorporate reasonably accessible, short circuit, protection elements, such as manually resettable circuit breakers or fuses, to prevent inordinately large or potentially dangerous battery discharge currents.

3.4.2. *Specification.* Manually resettable circuit breakers are permitted. Automatic resetting circuit breakers shall not be acceptable. Fuses are also permissible but shall be clearly labeled with respect to pertinent electrical rating for proper replacement. It is recommended that if fuses are employed, their proper replacements should be housed in the controller.

Short circuit protective components shall be located adjacent to the wheelchair battery.

To permit adequate time for compliance with these Standards, the effective date shall be one year from the date of their publication in the Federal Register.

Rationale. Short circuit protection components are clearly desirable since they offer protection against excessive, undesirable, electrical loads as well as short circuits. The resetting feature of automatic resetting circuit breakers is unacceptable since a possible danger may exist for the wheelchair user if inordinately high electrical current, caused by a malfunction, is maintained.

3.4.3. *Short Circuit Protection Test.* The adequacy of short circuit protection shall be determined by inspection of the submitted wheelchair, plus circuit diagrams.

3.5. *Electrical-Energy Conductance.*

3.5.1. *Standard.* All electrical components shall transmit current safely without developing excessive local temperatures.

3.5.2. *Specification.* The wheelchair shall be capable of operating at maximum slope-ascent, current-drain conditions for 10 minutes and at maximum speed on level terrain for one-quarter hour with complete safety and without excessive heat generation. User accessible surfaces will not exceed 50 deg. C. Temperature tests shall be conducted in such a manner so as to preclude undesirable ambient-temperature effects, e.g., indoors or outdoors on cloudy or cool days. The wheelchair chassis shall not be employed to conduct electrical current. All electrical components and assemblies shall be rated for that condition corresponding to maximum slope-ascent current.

3.5.3. *Electrical-Energy Conductance Test.* At the conclusion of the Range Test (para. 2.3.), user accessible portions of the wheelchair shall be examined with a thermometer to measure surface temperature; temperatures greater than 122 deg. F. (50 deg. C) are unacceptable. Circuit boards, insulation, etc., shall be inspected for signs of excessive temperature such as discoloration. Electrical current between the battery and wheelchair frame shall not be permissible. Inspection of connector contacts is required to assure no loss of electrical effectiveness as a result of the Range Test.

3.6 *Rain Operation.*

3.6.1. *Standard.* Powered wheelchairs intended for outdoor usage shall be capable of operating in heavy rain without mechanical or electrical difficulties.

3.6.2. *Specification.* Rain shall not impair the function of Class III electric wheelchairs aside from reduction of traction resulting from wet surfaces.

3.6.3. *Rain Operation Test.* A Class III wheelchair, under test, shall be sprayed by a shower or equivalent spray device. Cold fresh water shall be used in amounts simulating heavy rain intensity, $\frac{3}{16}$ in. (4.75 mm), during a 10-minute period, after which the wheelchair is to be driven immediately. Observations of function during the subsequent period shall focus on possible power loss and control difficulties. Any significant reduction in performance, control, or safety caused by the simulated rain is unacceptable, with the singled exception of that natural reduction in available traction resulting from wet tires.

Class I and Class II wheelchairs are exempted from this test.

4.0. *Power Drives.*

4.1. *Disengagement.*

4.1.1. *Standard.* All electrically powered wheelchairs shall roll when a moderate force is applied to the push handles by an attendant.

4.1.2. *Specification.* Wheelchairs shall be acceptable if the maximum push force, to maintain motion, does not exceed 20 lbs. (89 N) when pushing the wheelchair by the push handles in a straight line on a horizontal, hard, flat surface at a negligible speed. This may be accomplished by the use of an easily accessible disengagement mechanism for attendants to release the drive wheels from the power-drive system. Removal or addition of components or subassemblies to achieve this requirement shall not be acceptable.

Rationale. It is imperative that an attendant be able to readily push a disabled wheelchair. The 20-lb. (89 N) force is four times that required to

initiate movement in a manually propelled wheelchair according to Veterans Administration Standard Federal Register, Vol. 42, No. 239, Tuesday, December 13, 1977), Para. 3.2.5.4.2.

4.1.3. *Power-Drive Disengagement Test.* The powered wheelchair, plus standard test load (Para.. 1.2.), shall be placed in a simulated power-failure condition upon a flat, horizontal, hard surface. The drive disengagement device, if any, shall be employed. (Active disassembly of the wheelchair, or any portion thereof, shall not be acceptable as a form of disengagement device.) The force required to propel the chair at a negligible speed shall be measured with a suitable force gauge such as a dial push-pull gauge. The measured force magnitude must not exceed 20 lbs (89 N)

4.2. *Types and Appropriate Safeguards.* Although different power-drive systems may be used, each shall provide maximum safety for the user.

4.2.1. *Belts.* Belts are used to transfer power from motors or speed reducers to drive wheels. The wheelchair shall incorporate guards, covers, side panels, and any other suitable safeguards that preclude pinching, jamming, and catching the occupant's anatomy and clothing.

4.2.2. *Chains.* Suitable guards shall be incorporated to preclude contact between the chain drive and the occupant's anatomy and clothing. Dripping of lubricants from the wheelchair is unacceptable.

4.2.3. *Friction Gear and Other Exposed Drives.* Suitable guards or side panels shall be employed with friction drives to preclude contact between the drive components and any part of the occupant's anatomy or clothing. Only automatically adjusting mechanisms which engage the friction drives with the tires shall be acceptble.

Rationale. Friction drives are subject to inordinate tire wear and gouging for several reasons including low tire pressure, chassis flexion, and wheel concentricity. Spring-loaded mechanisms, for instance, ameliorate these problems.

4.2.4. *Tires.* All requirements of Veterans Administration Standards Federal Register, Vol. 42, No. 239, Tuesday, December 13, 1977) shall be met.

4.2.5. *Powered Wheels.* These drive mechanisms are housed within drive wheels or hubs. Safety considerations shall match those for conventional wheelchairs. (Veterans Administration Standard, Federal Register, Vol. 42, No. 239, Tuesday, December 13, 1977.)

Rationale. Protective arrangements, such as guards or shields, are required to assure safety of the wheelchair occupant from all types of drive configurations. Exceptions are powered wheels since their configurations are not unlike conventional wheelchairs. However, these chairs should incorporate side panels and any other protective features similar to conventional wheelchairs.

4.2.6. *Add-On Power Packages.* The manufacturer shall be required to list all manually propelled wheelchairs that are claimed as suitable and compatible with the add-on power pack. Listed data shall include the manufacturer, style, model name, and model number of the wheelchair.

4.2.7. *Power-Drive Safeguard Test.* The adequacy of power-drive safeguards shall be determined through inspection of the submitted wheelchair by qualified professional personnel. Any design configuration leading to contact between the user and wheelchair segments capable of causing soft tissue or other trauma shall be rejected. Similarly, any design configuration leading to contact between the user and wheelchair segments capable of tearing or soiling the clothing of the user shall be rejected, except in the case of accidental loose or trailing clothing.

5.0. *Stability.*

5.1. *Occupant Stability.* Class II and Class III wheelchairs shall be equipped with body restraints such as seat belts or torso harnesses.

Rationale. The higher speeds and accelerations of Class II and Class III wheelchairs require the use of body restraints to offer adequate user stability. Those occupants lacking natural stability are in particular need of such restraints.

5.1.2. *Occupant Stability Test.* The adequacy of occupant stability shall be determined by inspection of the body restraint incorporated into the configurations of Class II and Class III wheelchairs.

5.2. *Wheelies.*

5.2.1. *Standard.* Maximun wheelchair acceleration shall not cause uncontrolled or unrestricted lifting of wheels during normal use.

5.2.2. *Specification.* This requirement shall apply on level surfaces, as well as on inclines, reflecting the ascending capability of the wheelchair with an actual or simulated wheelchair occupant. Wheelies shall be limited by any reasonable means, e.g., acceleration limiters or antitipping devices mounted on the rear of the wheelchair. Antitipping devices or any other mechanical methods that are used to limit wheelies action shall not prevent the wheelchair from traversing such common obstacles as door saddles, curb cuts, or short inclined surfaces.

5.2.3. *Wheelies Test.* The wheelchair shall be accelerated to the greatest extent possible in reverse and forward directions so as to seek that combination of consecutive accelerations producing the greatest fromt wheel lift-off. Regenerative brakes or automatic brakes are to be employed in this procedure; wheel locks or manual brakes are not to be applied. The maximum lift-off observed shall not exceed 3.0 in. (7.6 cm) between the ground and the bottoms of the caster wheels if no means to limit wheelies is evident. Maximum lift-off may be greater if some effective means to limit wheelies is evident. Under no circumstances shall the wheelchair topple in any direction. This test shall be conducted on a flat, horizontal, non-slip surface at standard load (Para. 1.2.) and half-standard load weight conditions. This test shall also be conducted on an inclined surface at an angle corresponding to the class capabilities given in Para. 2.2.2.

5.3. *Turning on a Ramp.*

5.3.1. *Standard.* Electrically powered wheelchairs shall be capable of turning on an incline while providing adequate stability to the occupant.

5.3.2. *Specification.* Electrically powered wheelchairs with a 200-lb. (90.7 kg) test load shall be capable of 180-deg. turns on a ramp.

Rationale. A powered wheelchair with its occupant must be able to change direction safely or accelerate on a ramp. The wheelchair may exhibit an increased tendency toward instability at maximum inclination, especially with occupants who have unusual body-weight distributions. Narraow wheelchairs with small bases may exhibit an undesirable tendency to tip over sideways at maximum inclination even at low speeds.

5.3.3. *Turning on a Ramp Test.* The wheelchair, carrying a standard load (Para. 1.2.), shall execute half-turns (180 deg.) or broken U-turns upon a ramp of standard slope (Para. 1.2.). Turns shall be performed in both uphill and downhill directions. Velocity during the turn shall be reasonably small to preclude significant inertial effects. Lift-off of any wheel exceeding 0.4 in. (1 cm) shall not be acceptable.

5.4. *Caster-Wheel Flutter.*

5.4.1. *Standard.* Caster-wheel flutter shall not be acceptable.

5.4.2. *Specification.* Caster-wheel flutter which cannot be removed with relatively minor action shall not be acceptable.

Rationale. The effect of flutter, especially at higher speeds, is to induce wheelchair vibration to decrease the stability of the wheelchair and to diminish the control which may be exercised by the user. Additional drag may also result.

5.4.3. *Caster-Wheel Flutter Test.* The caster wheels shall be observed over the full range of velocities and loading conditions; the test driver shall accelerate the wheelchair so as to seek that combination of velocity, load, and acceleration, if any, capable of causing flutter. Loading is to be varied in the range from half to full test load by employing drivers of different weights and/or suitable inanimate loads. All tests shall be conducted on smooth level terrain. Observations of flutter shall be conducted by the wheelchair driver or an observer from a short distance.

If flutter is evident but subsequent minor adjustments to the caster-wheel assembly eliminate such flutter, then the wheelchair under test shall be considered free of flutter.

5.5. *Tracking.*

5.5.1 *Standard.* Sudden removal of power from the drive motors shall not result in excessive veering of the wheelchair.

5.5.2. *Specification.* Powered wheelchairs shall not deviate from a straight line path by more than 10 deg. following the shutdown of power.

5.5.3. *Tracking Test.* A sheet of paper, roughly 4 ft. (122 cm) by 8 ft. (244 cm), which serves as test record, is taped to a flat horizontal floor. The wheelchair, while carrying a full test load, is driven on a straight path at a maximum speed over the paper in the direction of the long dimension. After the paper is initially traversed, the controls are released, and the wheelchair comes to a stop. Tire tracks (dirt) on the paper permit construction of the wheel path. Veering is shown by an angular difference between, before and after braking portions of the tracks and is measured by a protractor. The angle to be measured is that between the ideal straight line path, if veering did not occur, and the line drawn between the wheelchair location when power was removed and the final wheelchair location.

Should the wheelchair be equipped with a braking means, other than regenerative, capable of reducing velocity upon manual or other actuation, such brakes will also be tested in the manner given above. Application of such brakes will be made initially traversing the paper. Veering will be measured as given above.

Parking and other locking type brakes shall not be employed during this test.

5.6. *Obstacles and Ground Clearance.*

5.6.1. *Standard.* The wheelchair and occupant shall remain stable while surmounting and traversing obstacles. Ground clearance shall be adequate to traverse curb cuts and uneven terrain.

5.6.2. *Specification.* Class I wheelchairs shall traverse obstacles 1.0 in. (2.5 cm) high and 4.0 in. (10.2 cm) wide with rounded corners (i.e., 0.25 in. or 6.0 mm radius). The wheelchair must negotiate these obstacles in either the forward or reverse direction from a maximum running start of 2.0 ft. (0.6 m). Class II and Class III wheelchairs shall traverse obstacles that are 2.0 in. (5.1 cm) high with rounded corners as given above.

Rationale. It is expected that powered wheelchairs will be required to traverse small obstacles, such as door saddles, during a normal day's activity. The requirement to traverse a rounded edge is intended to preclude tire damage. Class II and Class III wheelchairs are expected to negotiate curb cuts and poor driveway alignments.

5.6.3. *Obstacle and Ground Clearance Test.* Suitable wooden obstacles are to be prepared from the cross-sectional dimensions given in Para. 5.6.2. The obstacle length should equal, or exceed, the width of known wheelchairs. Fastening of obstacles to a smooth horizontal floor shall be accomplished with rigid fasteners such as screws or bolts. The wheelchair should be positioned at right angles to the obstacle with the appropriate wheel center (either caster wheel or drive wheel), 2.0 ft. (0.61 m), in a horizontal sense from the obstacle leading edge. Tests are to be conducted with the wheelchair operating in either forward or reverse directions. Carrying a standard test load (Para. 1.2.), the wheelchair is to accelerate towards and surmount the obstacle from a standing start without damage to any portion of the wheelchair. Contact with any part of the wheelchair, exclusive of the wheels or antitipping devices, shall be viewed as evidence of inadequate ground clearance.

6.0. *Structural Requirements.* The structural requirements of a powered wheelchair shall be commensurate with its overall performance and intended purpose. The higher performance wheelchairs, Class II and Class III, intended for use outdoors or on mildly uneven terrain, shall be sufficiently strong to withstand the stresses of higher performance.

6.1. *Class I Wheelchairs.* This class of wheelchairs shall meet the requirements of the structural tests for non-powered wheelchairs, excluding drop tests. These tests shall be performed with batteries, motors, and controllers installed. Where applicable, maximum velocities shall be used. Such tests are detailed in the Veterans Administration Standard Federal Register, Vol. 42, No. 239, December 13, 1977).

6.2. *Class II Wheelchairs.* These higher performance wheelchairs shall undergo structural tests similar to those for Class I wheelchairs.

Rationale. Higher performance, Class II, powered wheelchairs, compared to Class I types, will encounter greater stress due to greater speeds and increased drive torques to traverse uneven terrain and to climb steeper inclines.

6.3. *Class III Wheelchairs.* This class of wheelchairs shall be subjected to the same test requirements as Class I and Class II. However, the load, i.e., person or anthropomorphic dummy, requirements shall be increased by 25 percent.

Rationale. Twenty-five percent additional occupant load is estimated to represent the stresses imposed by operating on the uneven terrain for which these chairs are intended.

6.4. *Foldability and Portability.* It shall not be mandatory that powered wheelchairs of all classes be foldable. Wheelchairs which require assembly shall be readily assembled without need for special tools or fixtures.

Rationale. Powered wheelchairs typically weigh 150 lbs. when fully assembled. Such bulk is not readily portable and, therefore, need not be foldable. From extensive clinical evaluation, it is determined that most powered wheelchairs are rarely transported from one place to another. Exceptions are wheelchair users who have access to vans with power lifts.

6.5. *Battery Security and Accessibility.* Battery trays and batteries shall be secure on the wheelchair frame. While the batteries may be enclosed, reasonable access for routine maintenance is to be provided. Special tools shall not be required to assure security or to provide maintenance.

7.0. *Battery Chargers.* Battery chargers are considered to be part of the powered-wheelchair system and subject to the following requirements.

7.1. *General Characteristics.* Battery chargers shall be separate and distinct units that are not physically, electrically, or in any manner permanently connected to the wheelchair chassis. Only low magnitude DC voltages shall be transmitted to the wheelchair battery. The powered wheelchair shall not be operational when the charger is connected to the chair.

Exceptions to the concept of entirely separate charger and wheelchair devices (as compared to built-in or bolted-on) shall be permitted only for those combined chargers and wheelchairs able to achieve Underwriter Laboratory listing under appropriate mobile-use hospital and home test categories.

Rationale. Because of potential shock hazard, battery chargers comprising a portion of the wheelchair chassis or permanently connected to the chassis are not encouraged. Typical battery chargers are neither designed nor intended for mobile use.

7.1.1. *Cables and Connectors.* The DC-voltage pair shall be of such design and configuration that electrical connection shall be permitted directly to the wheelchair battery only from the output (low-voltage) side of the charger. The high-voltage line shall permit electrical connection only to standard, wall-mounted, grounded, power receptacles on the input (high-voltage) side of the charger. All connector contacts shall be appropriately designed to avoid potential short circuits.

Rationale. These precautions should be taken in order to avoid possible electrical shocks to wheelchair users or attendants.

7.1.2. *Voltage and Current.* Maximum charging rates and charging procedures shall be clearly shown on the front panel of the battery charger. The charger shall provide only one output voltage. Leakage current tests shall be performed and shall not exceed 0.5 ma.

7.2. *Battery-Charger Tests.* Only automatic battery chargers shall be recognized. These chargers shall incorporate ammeters that clearly show charging current; the face of the ammeter shall be labeled with charging current in amperes or qualitative words such as low, medium, and high.

Rationale. Battery chargers that do not automaticaly reduce the charging rate to near zero as the battery becomes fully charged, reduce the useful life of a battery because of evaporation of electrolyte. Automatic timers do not necessarily correct this problem.

7.2.1. *Charging Rates.* The automatic battery charger shall reduce the charging rate to less than one-half amp when a normal, physically and electrically sound battery attains a full charge. Following the initial surge current, maximum battery-charge rate shall be approximately c/10 (energy storage capacity divided by 10 hours). If two batteries are charged in parallel, then charge sharing features shall be incorporated into the system to preclude one battery from discharging into the other. Sequential charging is unacceptable if two or more batteries are used on one chair.

Rationale. Charging current limitations are based upon battery life and safety considerations.

7.2.2. *Overload Protectors.* A circuit breaker or fuse shall be incorporated into the charger. The circuit breaker shall be a manual-reset type.

8.0. *Control Systems and Components.*

8.1. *Documentation.* Powered-wheelchair shipments shall include schematics, operational and maintenance manuals, and complete parts lists providing sources of components, if other than the wheelchair manufacturer. Each and every part is to be listed. Model and serial numbers shall be permanently affixed and clearly visible on the wheelchair.

8.2. *General.*

8.2.1. *Control Interfaces.* The control interface (e.g., joystick, pneumatic tube, microswitch), if attached to or suspended from any part of the wheelchair occupant's anatomy, shall not cause skin abrasion or irritation when used according to design. The position of the control interface shall remain essentially constant.

8.2.2. *On-Off Switch.* The wheelchair shall have a reasonably accessible and easily operable, main power control available for its user.

8.3. *Speed Controls.* Electrically powered wheelchairs are normally equipped with proportional, variable, or adjustable speed controls. All powered wheelchairs submitted for evaluation must offer the occupant at least two distinct speeds. Wheelchairs that provide only one constant speed shall not be acceptable. All controls and switches shall be clearly labeled.

8.3.1. *Proportional.* A proportional speed control permits a wheelchair occupant to select speeds between zero and maximum in infinitesimal steps that depend on joystick excursion or force. This method is most desirable.

Rationale. A proportional control is preferred since it is easiest to operate. A proportional control also provides smoother wheelchair response and promotes optimal wheelchair speed usage.

8.3.2. *Variable.* A variable speed control permits the occupant to dial a single speed between zero and maximum in infinitesimal steps; the selected speed is maintained by the wheelchair until the occupant selects a new setting.

8.3.3. *Adjustable.* An adjustable speed control permits a wheelchair user to select one of two or more available fixed speeds. Under no circumstances shall this method be acceptable for a wheelchair with maximum speed over 3.0 mi/h (4.8 km/h). Power may be switched on and off with common switching components such as relays, microswitches, or toggle switches.

Rationale. Adjustable speed controls are generally acceptable for low speeds since jostling of the wheelchair occupant is generally minimal. However, at speeds in excess of approximately 3.0 mi/h (4.8 km/h), acceleration may be large; patients with flaccid muscles or tremors ususally find such controls extremely difficult to operate under such circumstances.

8.3.4. *Speed Selection.* Manually manipulated joystick assemblies with microswitches shall provide a minimum of two speeds for the occupant. The speed selections shall provide maximum speed and approximately half maximum speed. If three speed selections are available, then maximum speed and approximately two-thirds and one-third maximum speed shall be provided. The speed selection switch shall be readily accessible and easily operable by the user.

8.4. *Joystick Control.* Joystick controls may be operated by hand or finger manipulation, chin excursion, or any other convenient anatomical motion by the occupant. All controls shall provide readily accessible, main-power switches for wheelchair occupant use. Joystick controls shall be readily adaptable for left- or right-handed operation and readily adjustable. Joysticks shall provide the user with easy, convenient, and safe control of wheelchair movement. Their use shall not require excessive force, extremely fine motions, or extensively occupy the user's attention. Observation by experienced clinicians will be used to determine compliance with this Standard.

Rationale. In general, most quadriplegics experience some difficulty manipulating joystick accemblies incorporating microswitches.

8.4.1. *Manual Types.* Manually manipulated joysticks may be used to operate microswitch assemblies or proportional controls. Proportional controls are optional for use on Class I wheelchairs, suitable for indoor use, but shall be required for Class II and Class III wheelchairs. Joystick assemblies with microswitches are optional for Class I wheelchairs, suitable for indoor use, but shall be precluded from use on other types.

Rationale. Class II and Class III whellchairs provide ample evidence that proportional controls are necessary to effectively modulate vehicular speed and enhance control; proportional controls also permit smoother

acceleration than their microswitch counterparts.

8.4.2. *Chin Types.* Chin-manipulated joysticks shall be readily mounted on suitable adjustable brackets in close proximity to the wheelchair occupant's chin. Additional requirements, previously set forth, also apply.

8.4.3. *Oral Types.* Orally manipulated joystick controls, utilizing lips, tongue, or teeth, shall be avoided if possible. When absolutely necessary, oral controls shall be used only on Class I wheelchairs, suitable for indoor use. Orally manipulated controls shall be sufficiently flexible to preclude injury to any portion of the occupant's anatomy. Elements introduced into the mouth shall be readily cleaned or easily replaced. Requirements covered in preceding control sections shall apply.

Rationale. Occasionally, mouthstick-manipulated joysticks are prescribed for patient use. When these patients are fitted with conventional chin-control models, acceptance levels are higher due to increased comfort and cosmesis. Clinical experiences demonstrate that mouthstick and tongue switches are usually rejected by patients when more suitable alternatives controls are available. To this extent, pneumatic controls may be subject to the same reception, but the flexibility of a pneumatic actuator tube is a decided improvement over hand levels or joysticks. Pneumatic controls also require less head motion and are especially useful for the more severely disabled.

8.5. *Pneumatic (Breath) Controls.* Two types of pneumatic controls, momentary and latching, are recognized. The former requires continuous positive or negative air pressure to achieve and maintain wheelchair motion. Latching controls require momentary or intermittent, positive or negative air pressure to achieve, change, or cease wheelchair motion. A combination of momentary and latching actuators are acceptable in a single control system. Actuating pressures shall not require the active use of the diaphragm. Maximum actuating pressure shall not exceed 0.5 psi. An adjustable support bracket for the pneumatic tube(s) shall maintain its position under ordinary operating conditions.

8.5.1. *Momentary.* Momentary pneumatic controls may be used on all types of Class I wheelchairs. A choice of at least two speeds or an infinitesimally variable speed, adjustable from zero to maximum, shall be readily accessible to the wheelchair occupant. If two speeds are provided, then the lower speed shall be approximately half that of maximum.

Rationale. Momentary controls are inherently safe since cessation of pneumatically induced signals or commands cut off power to the drive motors.

8.5.2. *Latching (Holding).* A Class I wheelchair with a maximum speed of up to 3.0 mi/h (4.8 km/h) shall provide either a variable speed mechanism or a selection of at least two fixed speeds, as described above. If maximum speed exceeds 3.0 mi/h (4.8 km/h), then the speed control shall incorporate a variable speed mechanism or a selection of at least three fixed speeds, each of which incorporates acceleration limitation. Pneumatic latching controls shall incorporate a convenient and easily operable actuator for selection of power on-off and any automatic reset modes. This may be achieved with a pneumatic switch, microswitch, or any other actuator or auxiliary switch for power selection readily accessible to the wheelchair occupant.

Rationale. Latching controls are not as physically demanding (fatiguing) as momentary controls but require increased attention. For instance, cessation of pneumatic pressure in a momentary control immediately turns off power to the drive system of the wheelchair; a latching control requires some additional action on the part of the wheelchair user to effect the same action. Another consideration is that uneven surfaces or small obstacles may cause a wheelchair occupant to lose access to the pneumatic controller and create a potentially dangerous situation. Since this would not occur with a momentary controller, it is recommended that higher speed wheelchairs, which incorporate latching mechanisms, should be confined to essentially hard flat surfaces (not exceed 0.5 psi, Para. 8.5.).

Field tests will supply supplementary data concerning the interfacing of controls with users. In particular, the possibility of control limitations or restrictions arising from the various forms of handicap will be explored.

In the event of conflict between laboratory and field test results, field test work will be assigned the decisive role. Thus, control systems found inadequate for sufficient reason, by users, will be deemed unacceptable regardless of the outcome of laboratory tests.

8.6. *Other Types of Controls.*

8.6.1 *Standard.* Miscellaneous controls, i.e., those not specifically referenced in these Standards, shall be acceptable only upon demonstration of safety and utility.

8.6.2. *Specification.* By definition, specifications cannot be prepared for a novel control system; only lengthy clinical experience permits the construction of useful specifications.

Rationale. Experience has shown that sequential selection of wheelchair modes (e.g., forward, reverse, right turn, left turn, stop, etc.) has not been successful. Similarly, controls that rely on eyeball motion, such as ocular controls or automatic sequencing systems, have been found undesirable because of awkard operation and increased reaction time. Thus, unconventional controls, no matter how ingenious, require searching field tests to establish merit.

8.6.3. *Miscellaneous Control Tests.* Miscellaneous control systems are required to prove utility and safety characteristics through extensive field and laboratory tests. Test protocols are to be prepared to reflect the precise characteristics of a given system. Exemptions from the general tests for ruggedness and sturdiness, contained within these Standards, may be sought for those control systems clearly intended for limited use. For example, devices limited to apartment use only may be exempted from certain structural tests.

8.7. *Support Brackets.*

8.7.1. *Standard.* All wheelchair controls shall be mounted on suitable support brackets.

8.7.2. *Specification.* Brackets shall be sufficiently adjustable to fit all standard wheelchair configurations, inlcuding straight-back and semi-reclining, but retain sufficient rigidity to hold a preselected orientation throughout the course of typical day's use. The support bracket shall not prohibit patient entry or egress. No special tools shall be required to achieve desirable position and orientation of support brackets.

Rationale. Chin-control brackets must be sufficiently rigid to maintain the joystick assembly in close proximity to the occupant's chin and to resist forces generated by the occupant's chin during the course of daily activities. Early chin-control brackets did not offer this feature, and it was not uncommon for patients to be marooned after approximately three-quarters of an hour of use. Certain control elements, such as pneumatic tubes, are not subject to significant forces and must simply maintain the control element in close proximity to the occupant's mount. In this situation, goosenecks or flexible metal rods, if sufficiently rigid, shall be acceptable. All control devices, including manually manipulated joysticks, should be suspended on readily adjustable brackets and not

require attendants to use special adjustment tools.

8.7.3. *Support-Bracket Tests.* The safety, utility, and performance of support brackets will be determined from field test results (Para. 1.2.3.) in which handicapped users will employ test units on a trial basis. Any displacement, as distinguished from deflection, of the bracket shall be unacceptable. Should unusual tools be required to position the bracket, the bracket shall be deemed unacceptable.

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AGENCY PUBLICATION ON ASSIGNED DAYS OF THE WEEK

The following agencies have agreed to publish all documents on two assigned days of the week (Monday/Thursday or Tuesday/Friday).

This is a voluntary program. (See OFR NOTICE 41 FR 32914, August 6, 1976.)

Monday	Tuesday	Wednesday	Thursday	Friday
DOT/SECRETARY	USDA/ASCS		DOT/SECRETARY	USDA/ASCS
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DOT/FAA	USDA/REA		DOT/FAA	USDA/REA
DOT/FHWA	USDA/SCS		DOT/FHWA	USDA/SCS
DOT/FRA	MSPB/OPM		DOT/FRA	MSPB/OPM
DOT/MA	LABOR		DOT/MA	LABOR
DOT/NHTSA	HHS/FDA		DOT/NHTSA	HHS/FDA
DOT/RSPA			DOT/RSPA	
DOT/SLSDC			DOT/SLSDC	
DOT/UMTA			DOT/UMTA	

Documents normally scheduled for publication on a day that will be a Federal holiday will be published the next work day following the holiday. Comments on this program are still invited.

Comments should be submitted to the Day-of-the-Week Program Coordinator, Office of the Federal Register, National Archives and Records Service, General Services Administration, Washington, D.C. 20408.

List of Public Laws

Note: No public bills which have become law were received by the Office of the Federal Register for inclusion in today's **List of Public Laws.**

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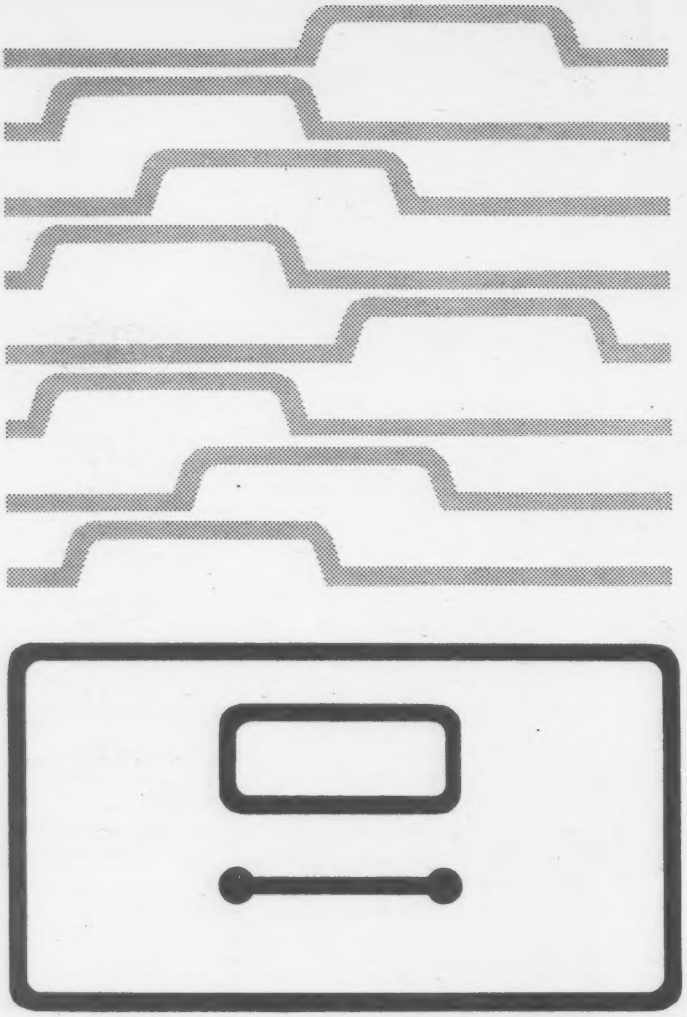

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